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The Commonwealth of Massachusetts

Department of Labor and Industries

DIVISION OF OCCUPATIONAL HYGIENE

OCCUPATIONAL HEALTH HAZARDS IN MASSACHUSETTS INDUSTRIES

IV. WOOD HEEL COVERING

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FOREWORD

The survey described in the following report is one of a series of industrial health studies conducted by the Division of Occupational Hygiene of the Massachusetts Department of Labor and Industries, in co-operation with the Works Progress Administration, as part of the Industrial Chemical Survey Project, W. P. A. No. 65-14-6060. This survey was supervised by Hervey B. Elkins, chemist, and W. C. L. Hemeon, engineer of the division. The purpose of this work is to secure, as a basis for constructive preventive effort, knowledge of the extent and manner of use of the more important potentially hazardous chemicals in the industries of the Commonwealth. The wholehearted assistance of the establishments visited is gratefully acknowledged.

THE SERVICES OF THE DIVISION OF OCCUPATIONAL HYGIENE ARE AVAILABLE ON REQUEST IN CONNECTION WITH MATTERS PERTAINING TO THE HEALTH OF INDUSTRIAL AND MERCANTILE WORKERS.

OCCUPATIONAL HEALTH HAZARDS IN MASSACHUSETTS INDUSTRIES

IV. WOOD HEEL COVERING

Heels for women's shoes are commonly made of wood to the surface of which a decorative covering material is attached. Covering wood heels is an industry in its own right, the cut heel blocks being usually purchased from wood heel block manufacturers and selected coverings applied to the surface according to market demands.

According to a census taken in 1934 (Division of Statistics, Department of Labor and Industries) there were 41 establishments engaged in the wood heel covering business employing a total of 1249 employees. This number includes 3 who make their own blocks.

In the course of the survey 13 of these plants employing 508 persons were visited, and air analyses were made in 8. The plants range from the very small workshop employing 9 workers to the largest which employed 200. The next largest employed 65 workers and the median number of workers in all plants visited was 35.

Several volatile solvents are used at various stages in the manufacturing process and these are listed in Table I.

TABLE I.

Substance	Composition	Method of Use
I Crude wood alcohol	Methanol (methyl alcohol; wood alcohol) acetone, miscellaneous impurities.	Softening celluloid heel covers in covering room.
II Pyroxylin cement	Methanol, acetone, butyl and methyl acetate or amyl acetate or ethyl and methyl acetate.	Cementing celluloid cover to heel.
III Lacquer	Toluol, ethyl acetate, Methyl acetate, methanol.	Spraying finished heels.
IV Rubber cement	Benzol	Breasting fancy heels (1 plant)
V Rubber cement	Naphtha (gasoline)	Attaching fancy leather covers.

Compositions I and II in this table are used in the covering room, III in a separate department and IV and V in the fancy covering departments. All except the methanol used in the covering room were used in such a mannr or in such small quantities that hazards to health seemed unlikely to be important. Attention was consequently directed entirely to determinations of the concentrations of the methanol vapor in the various covering room atmospheres.

Of 508 employees in the plants visited 209 or 41% work in the covering room. Applying this same proportion to the census figures referred to above it appears that between 500 and 600 workers are exposed to methanol vapors in wood heel covering plants in this state.

TOXICITY OF METHANOL

Chemically pure methanol is poisonous to the human body whether ingested as a liquid by mouth or breathed as vapors in air. It has particular affinity for nervous tissue and is most likely to affect the optic nerve and to produce blindness, either temporary or permanent. Fatalities, although rare, have been known to occur as a result of exposure to its vapors.

Like other poisons the body can ingest limited quantities and dispose of them without apparent harm. It is of great practical importance to know what this limit is in terms of concentration of the vapor in air a person may breathe during his working day and over a long period of time without suffering ill effects. This has been assumed to be 100 parts per million by the Division of Industrial Hygiene of the New York Department of Labor ("Dangers in the Manufacture and Industrial Uses of Wood Alcohol" Special Bulletin, Dec., 1917). More recently the U. S. Bureau of Mines has conducted extensive animal experiments which indicate that 200 parts per million parts of air or lower is a good hygienic condition (Private communication, August, 1936). This figure of 200 parts per million has been adopted by us as a standard of safety.

There was observed during the course of these investigations considerable misapprehension regarding the toxicity of methanol in the opinion, widely held, that it is the impurities in methanol that are toxic. Sayers and Yant ("Observations and Notes on the Effect of Methanol Antifreeze on Health." U. S. Bureau of Mines Inform. Circular 6415, Dec., 1930) make the following comment on that score:

> "It has been shown beyond doubt that methanol is a poison. . . . Also there is no practical difference between the toxicity of crude and refined methanol made by the wood distillation process and that made by the recent synthetic process. Further, it cannot be made non-poisonous by any known method or process. These facts need emphasis because some persons have held the erroneous opinion that the poisonous action of methanol is due mainly to impurities and that the purified product is relatively less toxic."

Similarly McCord has this to say on the same subject (Industrial & Engineering Chemistry, 23, p. 931, Aug., 1931):

> "For a generation the entire situation was confused because of the theory that impurities in methyl alcohol were responsible for all the harmful action attributed to the basic substance. The uninformed still, on rare occasions, maintain that highly purified methyl alcohol is harmless."

The impression is widespread in the wood heel covering industry that the vapors of a "poor grade" of methanol will cause eye irritation and that a "good grade" will not. Various manufacturers claim to have proven this point by attempted substitutions in the covering room which were detected by the workers. A possibility exists that variations in the amounts of certain impurities commonly present in crude wood alcohol such as pyridines and allyl alcohol may, by causing external irritation of the eyes when present in larger quantities, explain these reports. This aspect was not investigated further.

These observations, however, should not be permitted to obscure the important fact, as previously brought out, that methanol is a poison in its own right and is capable of causing serious internal derangements by breathing of excessive quantities of its vapors.

COVERING OPERATIONS

The operations in covering heels are few and simple. The only operation prior to covering is one of sanding the surfaces of the heel block to make them perfectly smooth.

The decorative covering attached to the heel may be of two types. It may be of leather or imitation leather, so-called "fancy heel covers", or it may be of celluloid. The "fancy heel covers" cut to shape are cemented to the heel by means of rubber latex cement and naphtha-rubber cement, the latex cement being applied to the heel and the naphtha cement to the cover.

APPLYING CELLULOID COVERS

In applying celluloid coverings to heels advantage is taken of the fact that on soaking this material in methanol (methyl alcohol or wood alcohol) it is made soft and limp and on drying regains its hard and horny character. A large number of the celluloid heel covers are soaked in small covered pans containing methanol and for this purpose natural methanol which contains a large proportion of acetone is used. The softening solution is made up of three parts of this methanol and one part water. The pans are in most cases kept covered to keep the solution strong enough for softening purposes. If the solution is too strong, the pan is uncovered to permit evaporation of methanol; otherwise the celluloid might become too soft. A half dozen or more are removed from the pan as needed and placed immediately while dripping wet between the folds of a towel which rests on the bench near the operator.

The effect of the towel is to remove excess liquid methanol solution from the covers without actually drying them. Methanol is continually evaporating from the outer surface of the towel into the surrounding atmosphere. One cover at a time is taken from this small pile, the excess of methanol removed by wiping on the palms of the hands and on the operator's apron and then stretched over the face of a wood heel held in a vise and which has previously received a coating of pyroxylin cement. It is pressed and shaped around the heel, trimmed at the corners, the edges cemented with the same pyroxylin cement, and the finished heel still damp placed on the bench near the operator. It is entirely a hand operation.

Celluloid covers are frequently embossed before application to the heel for decorative purposes. This is accomplished by pressing the soaked covers between metal plates whose surface is cut according to the pattern desired. The small screw press in which this is done is large enough to hold several layers of plates and covers alternately.

Women are employed for the covering work and are paid on a piece-work basis. Frequent wetting of the hands with methanol in doing this work often results in cracked skin on hands and fingers.

PRESENT METHODS OF VENTILATION

Rooms in which covering operations are conducted are required to be fireproof by reason of the inflammable character of the celluloid and methanol. The celluloid covers are stored in fireproof vaults. Interior walls are usually lathed and plastered and communicating doors between it and the other parts of the building are required by fire department regulations to be kept closed.

All establishments visited were ventilated by means of one or two propellor fans drawing air from the interior and delivering it to the exterior. Fans of this type are characterized by marked reduction in capacity when even slight resistance to flow of air is interposed. It is not at all uncommon for covering rooms to be so well insulated against the spread of fire that when doors are closed the capacity of the fan is reduced to a fraction of that when doors are open to provide a free means of entrance for air into the room.

General ventilation as provided by such fans may be adequate for small rooms if there is a ready means of entrance for the air (as obtained when communicating doors are open). For large rooms, it is entirely inadequate to keep the concentration of methanol vapor down below 200 parts per million.

RESULTS OF ATMOSPHERIC ANALYSES

The results of the survey are summarized in the following table:

Table II

Plant No.	Air Analysis Methanol Vapor Parts per Million of Air			Room Volume Cubic Feet per Person	Exhaust Fans (Propellor)	
	1	2	Average		No.	Size
1	700	880	780	390	2	
2	470	480	475	200	1	8″
3	280	450	365	1,180	2	18″
4		320	320	500	1	18″
5	135	280	210	1,300	1	12″
6	110	260	185	1,140	1	18″
7	170	190	180	1,550	2	
8	125	200	160	670	1	12″

PRINCIPAL SOURCES OF VAPOR

There are four stages in the process of covering the wood heel in each of which evaporation of methanol may occur to contaminate the atmosphere:—

1. In which celluloid covers are soaking in the pan of methanol. These pans are usually covered.
2. In which the soaked covers, removed from the soaking pan are temporarily stored between the folds of a towel on the bench.
3. In which a wet cover is removed from the towel and cemented to a heel.
4. In which the covered heel is resting in the open on the bench to dry.

It was of interest to determine the relative proportion of vapors arising in each stage of the various operations. This was done in the following manner:

Into an air tight glass jar was placed a bunch of dripping saturated covers that had been picked out of the soaking pan by the operator and placed directly in the bottle instead of being laid on the towel.

Into a second jar was placed a number of covers as individually picked off the pile on the towel for application to the heel, but before any of the excess methanol was wiped off.

The third bottle received a number of covers stripped off a wood heel after being stretched thereon but just before cement was applied.

On returning to the laboratory the total weight of wet covers and container (which was tightly closed right after receiving the covers) was determined. The containers of all three bottles were then spread out and allowed to dry overnight in the air, at room temperature. This data enabled us to determine the weight of alcohol held in each batch of dry covers by weighing the air dried covers. By converting into an equivalent basis of 100 grams of dry covers, it is possible to calculate the loss and weight by each operation. These results are set forth in Table III.

Table III

Stage of Operation	Wt. of Wet Covers	Wt. of Air Dried Covers	Wt. of Alcohol by Difference	Gms. Alcohol per 10 Gms. Dry Covers	Loss in Wt. Between Indicated Stages	% Loss for Each Operation
As picked from soaking pan but *before towel.*	39.1 gms.	28.0 gms.	11.1 gms.	39.6 gms.	13.1 gms.	33.0%
As picked *from* folds of *towel* but before applied to heel.	31.5 gms.	24.9 gms.	6.6 gms.	26.5 gms.	6.5 gms.	16.4%
Stripped from heel but before cementing.	32.3 gms.	26.9 gms.	5.4 gms.	20.0 gms.	20.0 gms.	50.6%
Completely air dried			zero	zero		
Total					39.6 gms.	100.0%

The figures in the above table indicated that about one-third of the vapors in the room come from methanol that evaporates from the towel resting on the bench; that only about one-sixth evaporates during the actual manipulations of the operator, that is when cover and heel are in her hands; and that one-half of the original methanol remains with the finished heel, most of which will evaporate into the atmosphere as it rests on the bench.

It is plain to see from the foregoing figures that by preventing escape of methanol vapors from the finished heels, a great reduction in the concentration of methanol in the atmosphere will be realized. By controlling vapors from the storage towel a reduction of about one-third should be attained. It will obviously not be necessary to consider exhausting the operations in the workers' hands since it has been shown that they account for only about one-sixth of all the methanol evaporated.

A ready solution to this problem then, is in providing a simple hood which encloses these areas (those where damp towel and finished heels lay) on three sides and top and connecting the hood to an exhaust system. A very small volume of air will suffice to provide a linear velocity of air at the open face of the hood of 50 to 70 feet per minute. This velocity should be adequate to prevent escape of vapors into the atmosphere since the source will be entirely enclosed, except in front, and no disturbing air currents will originate within that enclosure. Indeed, in the case of the towel for holding damp heel covers, very little evaporation is desired, hence, an excessive velocity of air through that hood is to be avoided.

As operations are usually conducted, the wet towel rests on the bench to the left of the operator, and finished heels are placed on the bench area to her right. This would mean separate hoods on each side if her habits are not to be interfered with. However, where atmospheric analyses indicate methanol vapor of 300-400 parts per million or less, a single hood enclosing the finished heels may be sufficient to halve the concentration and bring it down below the safe limit of 200 parts per million.

No measurements were made to indicate the relative amounts of vapors which come from the embossing press. They can readily be handled, however, in a manner similar to that indicated in the preceding discussion, or the press can be kept covered except when loading and unloading.